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Research Article

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Bio-economic production potentiality of *Solanum lycopersicum* under smart agroforestry practice

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ABSTRACT

Food security and maximum land use system are the priorities of crop production technique in the present global food growing environment. The tomato-*Albizia lebbck* agroforestry is an effective smart production approach. The aim of this research is to find out the appropriate combination of organic mulch leads the tomato *Albizia lebbck* agroforestry production as compared to sole cropping technique for growth, yield, and quality that brings health hygiene for fresh and cooked consumption. The experiment was laid out following two factors split plot design with three (3) replications. Tomato in open field (T_0) and tomato under *Albizia lebbeck* woodlot agroforestry system (T_1) were arranged in main plots. Conversely, the usage of organic mulches was set in sub-plots viz. M_0= No mulch, M_1= Ash mulch, M_2= Saw dust mulch, and M_3= Water hyacinth mulch. The results indicated the highest yield (32.65 t/ha) was found in water hyacinth mulch (M_3) and the lowest yield (21.37 t/ha) was detected in M_0 without mulch (control). The treatment M_3 (water hyacinth mulch) gave the maximum sugar-acid ratio (12.04%) and minimum sugar-acid ratio (9.42%) was found in control (no mulch). Furthermore, the result showed the production potentiality was the highest yield (29.41 t ha^{-1}) was found in tomato- *Albizia lebbeck* agroforestry (T_1) and the lowest yield (25.95 t ha^{-1}) was recorded in sole cropping of tomato (T_0). The maximum sugar-acid ratio (11.37%) was found in tomato- *Albizia lebbeck* agroforestry (T_1) and the minimum sugar-acid ratio (10.31%) was found in sole cropping of tomato (T_0). On the other, the combined effect tomato- *Albizia lebbeck* agroforestry with water hyacinth mulch gave the highest yield (35.01 while, the lowest yield (22.47 t ha^{-1}) was observed in sole cropping of tomato without mulch. The research finding also revealed the maximum benefit-cost ratio (4.94) was found from the tomato- *Albizia lebbeck* agroforestry which was 20 % higher than tomato was grown in sole cropping. Finally, the tomato- *Albizia lebbeck* agroforestry production in association with organic hyacinth mulch can be an effective production approach for maximum return in terms of yield, quality and money.

KEYWORDS: Smart agroforestry, Organic mulch, *Solanum lycopersicum*, and Multipurpose woodlot

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INTRODUCTION

The depletion and destruction of forests create the issue of food insecurity directly by impacting fruit production and other forest and tree-based food items as well as modification of the ecological factors important to crops and livestock and thereby affecting food supply (van Noordwijk *et al.*, 2014). Food protection happens where all residents have physical and economic access to appropriate, healthy and nutritious foods always that satisfy their nutritional requirements and generate and deliver them to individuals' food tastes and health status (Mah *et al.*, 2014). Although amazing improvements in production there is evidence that traditional agricultural policies have not been able to eradicate world poverty, result in unbalanced, nutritionally deficient diets, raise people's vulnerability to high food markets, and fail to understand the ecological of enhanced agricultural processes over the longer term (FAO, 2013; FAO, 2014). Bangladesh is the world's eighth most heavily populated country having 163.7 million individuals with an area 147,570 square kilometers (BBS, 2018) 65 percent of the population lives in rural areas, and their livelihood depends mainly on agricultural activities (World Bank, 2016). The land area for agriculture has shrunk sharply due to rapid urbanization and industrialization. Over the last decade, 61,91% cultivated land and 27,77% vegetation covering reduced by replacing the urban morphology of major cities in Bangladesh (Hassan, 2017);

this trend is likely to get worse in the coming years (Hasan *et al.*, 2013). Additionally, it would not be adequate to fulfill the demands of the people living in rural areas to enforce the new scheme of land use with different allocations of agriculture and forestry (Hanif & Bari, 2013).

Besides, forests and tree-based systems can play a crucial role in supplementing agricultural production to provide better and more equitable nutrients for cooking (Vinceti *et al.*, 2013); wood for cooking; increased control of food consumption choices, especially during lean seasons and periods of vulnerability (including for marginalized groups) (FAO, 2011); This approach benefits local livelihoods, cultivation and food protection as essential environmental service providers (van Noordwijk *et al.*, 2012). Food sustainability, in all its facets, in an environment at risk of breaching global limits through its human exploitation and alteration of nature, atmosphere, water and nutrient cycles (Rockström *et al.*, 2009) implies an emphasis on food quality and diversity, beyond calorific volumes, and on simple choices to adopt suitable and sustainable diets to the anticipated population size and welfare goals (Bommarco *et al.*,2013). Climate-Smart Agroforestry (CSA) seeks to contribute to adaptation and tolerance of climate change in agricultural systems, while also contributing to mitigation (reduction of emissions) and food protection (Campbell *et al.*, 2014; World Bank, 2015). Agroforestry is a prime example (Rosenstock *et al.*, 2016); it includes the combination of agriculture and forestry between farmers and multi-scale animals, crops and forests. Agroforestry includes the combined cultivation of trees and annual crops in cropland areas (Coulibaly *et al.*, 2017). It involves processes such as intercropping, silvopasture and home planting (Yasmin *et al.*, 2010).

Climate-Smart Agroforestry (CSA) is a modern approach of multi-product cultivation practice that rises crop yields, ensure food security and optimistic livelihood outcomes (Sileshi *et al.*, 2009; Akinnifesi *et al.*, 2010). This approach would suitable, environmentally sound that meets the socio-economic needs of rural people (Mbow *et al.*, 2014; Chakraborty *et al.*, 2015). It can increase soil fertility; control soil erosion; boost the water quality, and improve biodiversity (Sharmin & Rabbi, 2016). It further reduces poverty by growing income and involves women in production activities (Leakey & Simons, 1998; Garrity, 2004). In this agroforestry system, *Albizia lebbeck* the fast-growing deciduous, nitrogen-fixing tree performed a highly significant role in combined vegetable production, the environmental sustainability by reducing the carbon dioxide also added more economic returns (Rahman *et al.*, 2017).

Universally, Solanaceae grouped nutritious and popular vegetables Tomato (*Lycopersicon esculentum* L.) is the top producing vegetable in terms of production, consumption, and commercial use (Amin *et al.*, 2017b). It contains enough vitamin-A, vitamin-C, calcium, iron as well as antioxidant lycopene that reduces the risk of prostate cancer (Matin *et al.*, 1996). Though, this vegetable crop has huge prospect all around especially in Bangladesh, but the use of chemical fertilizers, pesticides, hormones etc. create an unsustainable farming approach. Moreover, the mono cropping tomato production system reduces the soil fertility and natural resources result in climate change, health impacts, unstable incomes (Zaman *et al.*, 2006). It is important to use inputs and methods to boost the ecological equilibrium of natural systems to produce healthy, even nutritious foods. This arises because the organic crop is cultivated without pesticides, herbicides, highly soluble fertilizers.

Mulching is a useful water-saving technique (Stolz *et al.*, 2011; Biswas *et al.*, 2015), usually, the presence of mulch typically decreases the net radiation and increases the heat allocation in the soil, lowers the required surface energy and thus reduces ETc (Dlamini *et al.*, 2017). The physical barrier created by the mulch prevents the loss of water by evaporation, which also raises the temperature of the soil (Fan *et al.*, 2017) and can also induce early harvesting (Díaz-Pérez, 2009). Water evaporated from the ground is unproductive since it does not participate in plant physiological as well as metabolic processes. Also, mulch prevents weed growth (Moreno *et al.*, 2016). Sheppard *et al.* (2020) reviewed the potentiality and response of agroforestry for the alleviation of climate change. The FAO study further suggests that research supports the concept that forests and trees often make important contributions to the UNEP Sustainable Development Goals (SDGs) through the informal sector, gender equity, adaptation to climate change, and as part of a comprehensive approach to land depletion and biodiversity destruction (Kader *et al.*, 2017; Moreno *et al.*, 2013). AFS is commonly used in developed countries and is now a major land use system; in addition, at least 1.2 billion people around the world have been estimated to be relying on such schemes. Off-site advantages include decreased runoff, decreased loading of nutrients and increased water quality. Nevertheless, AFS can (and must) be complimentary to other current land uses. Organic production not only eliminates health risks for both farmers and customers, but also preserves and increases soil quality (Reith *et al.*, 2020). Rahman *et al.* (2011) investigated the output of tomatoes under various multistorey agroforestry development systems and found that except for plant height, all other morphological features were found. Hossain *et al.* (2014) reported that the economic performance of fruit tree-based tomato production system showed that both the net return and BCR of mango and guava-based system was higher over control and olive-based system. The contents of organic carbon, nitrogen, available phosphorus, potassium and sulfur of before experimentation soil were slightly higher in fruit tree-based agroforestry systems than the control. There is a plenty of scope to set a research in the production, quality and economic benefits of tomato grow under a multi-purpose tree woodlot influence by the organic mulch.

Thus, the existing land-use systems are insufficient to meet the demands of food, fuel, fodder, timber and other minor products in the 21st century. Given the above, the research aims to contribute a climate-smart agroforestry approach to organic and safe tomato production by using organic mulch under the *Albizia lebbeck* woodlots.

MATERIALS AND METHODS

Site of the Experiment

The experiment was conducted in Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The site was between 25º 13´ latitude and 88º 23´ longitude, and about 37.5 m above the sea level. The experimental plot was in a medium high land belonging to the old Himalayan Piedmont Plain Area (AEZ No. 01). Land was well-drained and drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 5.1 found in the field. The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty rainfall in the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period.

Experimental Design And Treatment

The experiment was laid out following a split plot design with three (3) replications. Tomato under *Albizia lebbeck* woodlot and tomato in open field were arranged in main plots T_0 = tomato sole cropping (control) and T_1 = tomato *Albizia lebbeck* woodlot agroforestry system. On the other hand, application of organic mulches was in sub-plots; M_0 = No mulch, M_1 = Ash mulch, M_2 = Saw dust mulch, and M_3 = Water hyacinth mulch. Total numbers of experimental plots were 24 (2 x 4 x 3. The unit plot size is 2.5m x 2.5m = 6.25 m^2. The total numbers of experimental plots were 2. The individual plot area was 4.5 m x 4.5 m = 20.25 m^2. Twelve (12) plots were laid under *Albizia lebbeck* woodlot agroforestry system and 12 plots were laid in the control (open field). The field research work was started in October 2018 and was completed in April 2019.

Crop Establishment

Tomato seedlings were raised in a seed bed situated on a relatively high land adjacent to the Agroforestry and Environment Research field. Five gram of seeds were sown in a seedbed on October 10th, 2018. Sown seeds were covered with light soil. Complete germination of the seeds took place within 7 days after sowing. The land of experimental plot was tilt in the 2nd week of October 2018 with spade and it was made ready for transplanting on 31th October 2018. The corners of the land were spaded and visible larger clods were hammered to break into small pieces. All weeds and stubbles were removed from the field. The layout was done as per experimental design. All basal dosages of fertilizer as per scheduled of the experiment was incorporated in the soil and finally the plots were made ready for planting. Twenty one days old healthy and disease free seedlings were uprooted from the seedbed and transplanted in to the main field on 31th october 2018 maintain spacing 15 cm plant to plant and line to line 10cm. All the organic mulching materials were applied in 15 days after transplanting in the plot i.e. 16 November 2018.

Samplings, Measurements, and Analyses

Five plants were selected randomly from each plot and tagged properly for data collection. For this purpose, the outer two rows of plants and the plants in the extreme ends of the middle rows were not considered for selecting the sample plants.

Data were recorded on the following parameters for yield contributing characters of tomato.

- Plant height (cm)
- Number of branch per plant
- Number of fruits per plant
- Individual fruit weight
- Fruit yield per plant
- Yield (ton per ha)

Data were recorded on the following parameters for fruit quality of tomato.

- Reducing sugar (%)
- Soluble sugar (%)
- Vitamin C (mg 100 g^{-1})
- Organic acid (%)
- Sugar-acid ratio (%)

Economic performance of tomato

For the evaluation the of tomato economic analysis under *Albizia lebbeck* woodlot agroforestry system along with sole cropping, the cost of cultivation, gross and net returns per hectare and benefit-cost ratio were calculated.

The cost of cultivation of the tomato under *Albizia lebbeck* woodlot agroforestry system along with sole cropping was estimated. Gross return is the monetary value of total product and by-product. Per hectare gross returns from tomato was calculated by multiplying the total amount of production by their respective market prices. Net return usually means the profit of the enterprises. Net return was calculated by deducting the total cost of production from the gross return.

Net return = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1})

Benefit-cost ratio is the ratio of gross return with total cost of production. It was calculated by using the following formula (Islam *et al.*, 2004).

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Total cost of production (Tk. ha}^{-1}\text{)}}$$

Data were statistically analyzed using the (ANOVA) "Analysis of Variance" technique with the help of the computer package MSTAT. The mean differences were adjusted by the Duncan's Multiple Range Test (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Effect of Organic Mulch on Growth, Yield, and Quality of Tomato

Effect of different organic mulches on the plant height, number of branches plant^{-1}, number of fruits plant^{-1}, individual fruit weight, fruit yield plant^{-1} was presented in the table 1. The plant height from the soil surface to the last opened leaves of the apex were recorded in the mature harvesting stage. The results revealed that the effect of organic mulches had significant variations over control. The highest plant height (131.70 cm) was recorded in M_2 and the lowest plant height (115.70 cm) was found in control treatment (M_0). Hossain (1996) recorded that plant height of garlic were significantly higher for mulched than unmatched plants. In a trail with organic mulches or polythene mulch on tomato a minimum effect had been observed on plant height by Srivastara *et al.* (1981). The highest number of branch plant^{-1} (14.16) was found in M_1 (ash mulch) which was followed by M_3 (water hyacinth mulch) and the lowest number of branch plant^{-1} (7.76) was found in control (M_0). Olasautan (1985) was found significantly higher number of branch/plant in tomato from mulched plants than unmulched plants. A similar finding was reported by Wojtaszek *et al.* (1977). Significantly the highest number of fruit plant^{-1} (48.42) was recorded in M_3 (water hyacinth mulch). On the other hand, the lowest number of fruit plant^{-1} (22.05) was recorded in M_0 control (no mulch treatment). Among all mulching treatments, the highest individual fruit weight (132.20 g) was recorded in M_1 (water hyacinth mulch) followed by M_1 (ash mulch). The lowest fruit weight (105.40 g) was recorded in M_0 control (without mulch). Medina *et al.* (2011) reported that all mulch treatment gave higher yield compared with the control. Significantly the highest fruits plant-1 (6.41 kg) was recorded in M3 (water hyacinth mulch) followed by M1 (ash mulch). On the other hand, the lowest fruits plant-1 (2.32 kg) was found in M0 control (without mulch), respectively. Tomato yield was differed significantly by the organic mulching (Figure 1). The highest yield (32.65 t ha^{-1}) was found in M_3 (water hyacinth mulch) which was followed by (30.04 t ha^{-1}) found in M_1 (ash mulch). The lowest yield (21.37 t ha^{-1}) was observed in M_0 control (without mulch), respectively. Medina *et al.* (2011) reported that all mulch treatment gave higher yield compared with the control.

The effect of organic mulch on the fruit quality (reducing sugar%, soluble sugar%, vitamin-C, organic acid ratio%) of tomato was found significantly different and the result was presented in the Table 2. Significantly the maximum soluble sugar (4.48%) was recorded in control treatment (M_0) that was statistically similar to (4.24%) found in M_1 (ash mulch) and the minimum soluble sugar (4.24) was calculated in M_3 (water hyacinth mulch). But in case of vitamin-C content, water hyacinth mulch (M_3) showed the maximum amount vitamin-C (14.58 mg/100g of tomato fruit) and the minimum vitamin-C (5.88 mg/100g of tomato fruit) was taken from control treatment (no mulch), respectively. The height percentage of organic acid (0.403) was measured in M_1 treatment which was statistically similar to M_2 and M_3 and the lowest percentage of organic acid (0.308) was found in control treatment. Finally, the treatment M_3 (water hyacinth mulch) gave the maximum sugar-acid ratio (12.04%) and minimum sugar-acid ratio (9.42%) was found in control (no mulch).

Table 1: Effects of organic mulch on yield contributing characters of tomato

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of fruits plant^{-1}	Individual fruit weight (g)	Fruit yield (kg plant^{-1})
M_0	115.70 d	7.76 d	22.05 d	105.40 d	2.32 d
M_1	123.30 b	14.16 a	38.75 b	119.80 b	4.64 b
M_2	131.70 a	11.79 c	30.53 c	115.70 c	3.51 c
M_3	118.1 c	13.12 b	48.42 a	132.20 a	6.41 a
Level of Significance	**	*	*	**	*
CV (%)	1.11	3.33	0.96	2.97	1.84

M_0= no mulch; M_1= ash mulch; M_2= saw dust mulch; and M_3= water hyacinth mulch.
Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT.
^{ns} Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

Table 2: Effects of organic mulch on fruit quality of tomato

Treatments	Reducing sugar (%)	Soluble sugar (%)	Vitamin C (mg·100 g^{-1})	Organic acid (%)	Sugar-acid ratio (%)
M_0	2.88	4.48 a	5.88 c	0.308 b	9.42 d
M_1	2.79	4.37 ab	12.02 b	0.403 a	11.31 b
M_2	2.75	4.31 bc	12.03 b	0.362 ab	10.62 c
M_3	2.74	4.24 c	14.58 a	0. 397 a	12.04 a
Level of Significance	ns	*	*	*	**
CV (%)	0.73	0.60	1.79	1.73	0.60

M_0= no mulch; M_1= ash mulch; M_2= saw dust mulch; and M_3= water hyacinth mulch.
Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT.
^{ns}Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

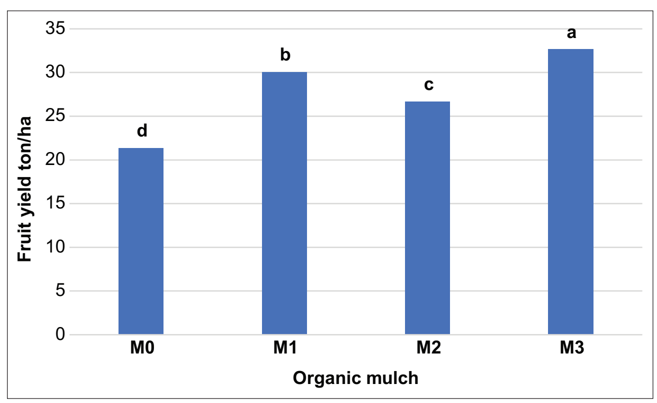

Figure 1: Effect of organic mulch on tomato fruit yield ton/ha
Bars with the same letter are not significantly different; bars with dissimilar letters indicate treatments which significantly differ based on DMRT

Effect of Two Production System on Growth, Yield, and Quality of Tomato

Tomato grown under *Albizia lebbeck* woodlot agroforestry system was more vigorous than grown in sole cropping i.e. in full sun light conditions (Table 3). In mature harvesting stage, significantly the highest plant height (132.2 cm) was observed in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the lowest plant height (122.2 cm) was observed in sole cropping of tomato (T_0). Hillman (1984) reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade. The highest number of branches plant^{-1} (12.57) was observed in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) whereas the lowest number of branches plant^{-1} (10.84) was recorded in sole cropping of tomato (T_0). Significantly the highest number of fruits plant^{-1} (35.81) was recorded in T_1 treatment (tomato- *Albizia lebbeck* agroforestry). On the other hand, the lowest number of fruits plant^{-1} (34.07) was found in sole cropping of tomato (T_0), respectively. The highest fruits weight (120.8 g) was recorded in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the lowest fruits weight (106.9 g) was found in sole cropping of tomato (T_0). The highest fruits plant^{-1} (4.44 kg) was recorded in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the lowest fruits plant^{-1} (4.01 kg) was found in sole cropping of tomato (T_0), respectively. Tomato yield was differ significantly due to the effect of two production systems (Figure 2).

The highest yield (29.41 t ha^{-1}) was found in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the lowest yield (25.95 t ha^{-1}) was recorded in sole cropping of tomato (T_0).

The effect of two production technique on the fruit quality (reducing sugar%, soluble sugar%, vitamin-C, organic acid ratio%) of tomato was recorded significantly varied and the result was showed in the table 4. Significantly the maximum soluble sugar (4.49%) was noted in sole cropping of tomato (T_0) and the minimum soluble sugar (4.22%) was considered in T_1 treatment (tomato- *Albizia lebbeck* agroforestry). The maximum amount vitamin-C (12.36 mg/100g of tomato fruit) was found in T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the minimum vitamin-C (9.90 mg/100g of tomato fruit) in sole cropping of tomato (T_0). The height organic acid% (0.388) was measured in tomato- *Albizia lebbeck* agroforestry (T_1) and the lowest organic acid% (0.348) was found in sole cropping of tomato (T_0). The maximum sugar-acid ratio (11.37%) was found in tomato- *Albizia lebbeck* agroforestry (T_1) and the minimum sugar-acid ratio (10.31%) was found in sole cropping of tomato (T_0).

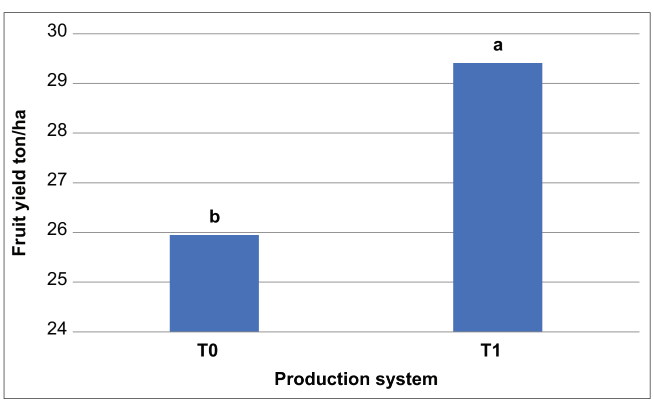

Figure 2: Effect of production system on tomato fruit yield ton/ha
Bars with the same letter are not significantly different; bars with dissimilar letters indicate treatments which significantly differ based on DMRT

Interaction Effect of Organic Mulch and Production System on Growth, Yield, and Quality of Tomato

The interaction effect of organic mulch and production system had significant differences on the plant height, number of branches plant^{-1}, number of fruits plant^{-1}, individual fruit weight, fruit yield plant^{-1} and the result was exposed in Table 5. The highest plant (146.60 cm) was observed in T_1M_2 treatment combination and the lowest plant height (106.70 cm) was found in T_0M_0 treatment combination, respectively. Significantly the highest branch plant^{-1} (15.75) was found in T_1M_1 treatment combination and the lowest number of branch plant^{-1} (7.20) was in T_0M_0 treatment combination. Significantly the highest number of fruit plant^{-1} (50.53) was found in T_1M_3 treatment combination. On the other hand, the lowest number of fruit plant^{1} (24.33) was recorded in T_0M_0 treatment combination. The highest individual fruit weight (135.40 g) was found in T_1M_1 treatment combination and the lowest individual fruit weight (104.20 g) was recorded in T_0M_0 treatment combination. The highest fruit yield plant^{-1} (6.85 kg) was observed in T_0M_3 treatment combination and the lowest fruit yield plant^{-1} (2.54 kg) was recorded in T_0M_0 treatment combinations, respectively. Yield (tha^{-1}) was found significantly different due to interaction effect of organic mulch and production system which was presented in Figure 3. Significantly the highest fruit

Table 3: Effects of tomato sole cropping and tomato- *Albizia lebbeck* agroforestry on yield contributing characters of tomato

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of fruits plant^{-1}	Individual fruit weight (g)	Fruit yield (kg plant^{-1})
T_0	122.2 b	10.84 b	34.07 b	106.9 b	4.01 b
T_1	132.2 a	12.57 a	35.81 a	120.8 a	4.44 a
Level of Significance	**	*	*	**	*
CV (%)	1.11	3.33	0.96	2.97	1.84

T_0 implies control, sole cropping of tomato; T_1 indicates tomato grown under *Albizia lebbeck* woodlot.
Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT
^{ns}Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

Table 4: Effects of tomato sole cropping and tomato- *Albizia lebbeck* agroforestry on fruit quality of tomato

Treatments	Reducing sugar (%)	Soluble sugar (%)	Vitamin C (mg· 100 g^{-1})	Organic acid (%)	Sugar-acid ratio (%)
T_0	2.85	4.49 a	9.90 b	0.348	10.31 b
T_1	2.73	4.22 b	12.36 a	0.388	11.37 a
Level of Significance	ns	*	*	ns	*
CV (%)	0.73	0.60	1.79	1.73	0.60

T_0 implies control, sole cropping of tomato; T_1 indicates tomato grown under *Albizia lebbeck* woodlot.
Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT
^{ns}Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

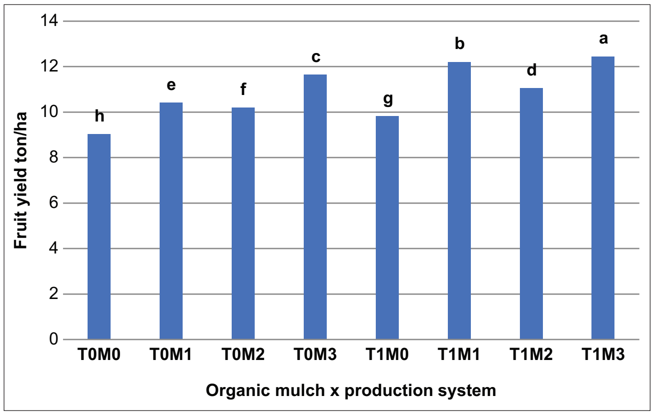

Figure 3: Interaction effect of organic mulch and production system on tomato fruit yield ton/ha
Bars with the same letter are not significantly different; bars with dissimilar letters indicate treatments which significantly differ based on DMRT

yield (35.01 t ha^{-1}) was recorded in T_1M_3 treatment combination. Conversely, the lowest fruit yield (22.47 t ha^{-1}) was recorded in T_0M_0 treatment combination, respectively.

The interaction effect of organic mulch two production system on the fruit quality (reducing sugar%, soluble sugar%, vitamin-C, organic acid ratio%) of tomato was noted significantly and the result was exhibited in the table 6. The maximum soluble sugar (4.62%) was found in T_0M_0 treatment combination whereas the minimum soluble sugar (4.10%) was measured in T_1M_3 treatment combination. The maximum amount vitamin-C (16.63 mg/100g of tomato fruit) was observed in T_1M_3 treatment combination and the minimum vitamin-C (5.10 mg/100g of tomato fruit) was observed in T_0M_0 treatment combination. Again, the height organic acid% (0.450) was recorded in T_1M_1 treatment combination which was statistically identical to T_1M_3 treatment combination. The lowest organic acid% (0.317) was found in T_0M_0 treatment combination. The maximum sugar-acid ratio (12.44%) was found in T_1M_3 treatment combination whereas the minimum sugar-acid ratio (9.02%) was found in T_0M_0 treatment combination, respectively.

Cost and Benefit Evaluation of Tomato-*Albizia Lebbeck* Agroforestry Compare to Sole Cropping of Tomato Production

The cost of production, gross and net return and benefit--cost ratio of tomato-*Albizia lebbeck* agroforestry and sole cropping of tomato was calculated on local market prices during the experimental time and the results was presented in table 7. The maximum cost of production (160500 Tk/ha) was calculated from T_1 treatment (tomato- *Albizia lebbeck* agroforestry), while the least production cost (130500 Tk/ha) was measured from sole cropping of tomato (T_0). The maximum return of gross money (79300 Tk per ha) was achieved from the T_1 treatment (tomato- *Albizia lebbeck* agroforestry) and the minimum return of gross currency (519000 Tk per ha) was taken from the sole cropping of tomato (T_0). Net return was maximum in tomato- *Albizia lebbeck* agroforestry (T_1) compared to sole cropping of tomato (T_0). It was observed that tomato- *Albizia lebbeck* agroforestry (T_1) gave the maximum net return (632500 Tk per ha). At the same time, the minimum net return (388500 Tk per ha) was received from the sole cropping of tomato (T_0).

Table 5: Interaction effects of organic mulch and tomato production systems on yield contributing characters of tomato

Treatments	Plant height (cm)	Number of branch plant^{-1}	Number of fruits plant^{-1}	Individual fruit weight (g)	Yield (kg plant^{-1})
T_0M_0	106.70 f	7.20 f	24.33 g	104.2 h	2.54 g
T_0M_1	113.20 e	12.57 c	36.40 d	116.8 e	4.25 d
T_0M_2	116.80 d	11.25 d	29.23 f	112.50 f	3.24 f
T_0M_3	112.30 e	12.34 c	46.30 b	129.0 b	5.97 b
T_1M_0	124.70 c	8.317 e	19.77 h	106.7 g	2.11 g
T_1M_1	133.50 b	15.75 a	41.10 c	122.7 c	5.04 c
T_1M_2	146.60 a	12.33 c	31.83 e	118.5 d	3.77 e
T_1M_3	123.90 c	13.90 b	50.53 a	135.4 a	6.85 a
Level of Significance	**	*	*	**	*
CV (%)	1.11	3.33	0.96	2.97	1.84

Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT.
[ns]Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

Table 6: Interaction effects of organic mulch and tomato production systems on fruit quality of tomato

Treatments	Reducing sugar (%)	Soluble sugar (%)	Vitamin C (mg 100 g^{-1})	Organic acid (%)	Sugar-acid ratio (%)
T_0M_0	2.94	4.62 a	5.10 f	0.317 bc	9.02 h
T_0M_1	2.84	4.52 ab	10.57 d	0.357 abc	10.41 e
T_0M_2	2.81	4.43 b	11.40 cd	0.340 bc	10.19 f
T_0M_3	2.81	4.38 bc	12.53 bc	0.377 abc	11.64 c
T_1M_0	2.82	4.33 bc	6.67 e	0.300 c	9.81 g
T_1M_1	2.74	4.23 cd	13.47 b	0.450 a	12.20 b
T_1M_2	2.70	4.20 cd	12.67 bc	0.383 abc	11.05 d
T_1M_3	2.67	4.10 d	16.63 a	0.417 ab	12.44 a
Level of Significance	ns	*	*	*	**
CV (%)	0.73	0.60	1.79	1.73	0.60

Columns with the same letter or without letter (s) are not significantly different. Columns with dissimilar letters indicate treatments which differ significantly based on DMRT.
[ns]Not significant; * significant at $p \leq 0.05$; ** significant at $p \leq 0.01$.
The CV indicates the ratio of the SD to the mean

Table 7: Economic return of tomato-*Albizia lebbeck* agroforestry compare to sole cropping of tomato production (one year)

Production system	Outcome (Tk/ha)		Gross Return (Tk/ha)	Total cost of Production (Tk/ha)	Net Return (Tk/ha)	BCR
	Tomato	*Albizia lebbeck*				
Tomato sole-cropping (T_0)	519000	………	519000	130500	388500	3.98
Tomato-*Albizia lebbeck* agroforestry (T_1)	588200	204800	793000	160500	632500	4.94

Tomato price 20 Tk/kg and the price of *Albizia lebbeck* wood 500 Tk/tree

Table 7 indicated that the maximum benefit-cost ratio (4.94) was gained from the T_1 treatment (tomato- *Albizia lebbeck* agroforestry), whereas the minimum benefit-cost ratio (3.98) was taken from sole cropping of tomato (T_0).

CONCLUSION

Smart agroforestry practice makes it possible to ensure balanced crop production by growing soil organic matter, ensuring careful maintenance, reducing the likelihood of crop losses, and verifying the maximum use of natural resources. It provides a healthy and sustainable method of production. The findings from the experimental results reveal that tomato- *Albizia lebbeck* agroforestry combined with organic mulch has given a significant outcome in terms of yield, quality, and economic benefits. In conclusion, the research finding indicates the benefit-cost ratio (4.94) from the tomato- *Albizia lebbeck* agroforestry as the organic mulch enhance the production and quality which was 20 % higher than tomato was grown in sole cropping. This production technique ensures not only the food safety, but also increases the income of the farmers and ensures the long-term sustainability.

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CONFLICT OF INTEREST

No conflict of interests for publication of this research paper.

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